MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

EME1046 – PRINCIPLES OF THERMODYNAMICS

(ME)

20 OCTOBER 2016
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 4 printed pages (including cover page) with five questions.
2. Attempt **ALL FIVE** questions. The distribution of the marks for each question is shown.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings MUST be shown.
5. A property tables booklet is provided.

Question 1 (20 marks)

a) A rigid vessel contains 2kg of refrigerant-134a at 800kPa and120 °C. Find
   i) volume of the vessel. (4 marks)
   ii) the total internal energy. (4 marks)

b) In a rigid tank contains superheated water vapor at 1.4MPa and 250 °C is cooled until the temperature drops to 120 °C.
   i) Draw a $T-v$ diagram for the process. (4 marks)
   ii) Determine the final pressure of the system (2 marks)
   iii) Determine the quality (3 marks)
   iv) Determine the final specific enthalpy (3 marks)

Question 2 (20 marks)

a) An isothermal compressor has been used to compress air from 150 kPa to 1100 kPa with temperature of 20 °C.
   i) Show the process on a $P-v$ diagram. (3 marks)
   ii) Find the change in specific volume of air as it passes through this compressor. (4 marks)

b) Figure 2b shows a rigid vessel containing 0.100 m^3 of a mixture of water-vapor at 100 °C with 12.3% quality. The vessel is then heated up until its temperature rise to150 °C.
   i) Find the specific volume and enthalpy for the initial state and final state. (7 marks)
   ii) Show the process on a $T-v$ diagram. (3 marks)
   iii) Calculate the heat energy that being transferred during the process. (3 marks)

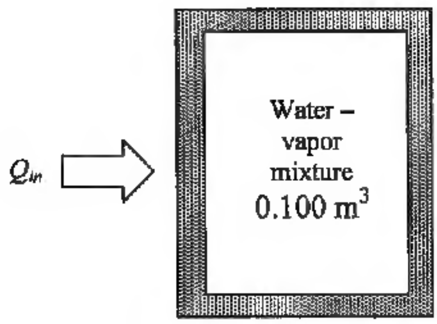

Figure 2b

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Question 3 (20 marks)

An adiabatic steam turbine receives steam from two different sources, as shown in Figure 1. The pressure and temperature at state 1 are 7 MPa and 700 °C and the mass flow rate is 10 kg/s. At state 2, the pressure and temperature are 1 MPa and 500 °C, and the mass flow rate is 5 kg/s. The exit state 3 is given by 30 kPa and 95% quality. You may ignore potential and kinetic energy changes through the device.

a) What is the exit volumetric flow rate in m^3/s? (7 marks)

b) What is the work done by the turbine in kW? (6 marks)

c) What is the rate of entropy generation for this process? (7 marks)

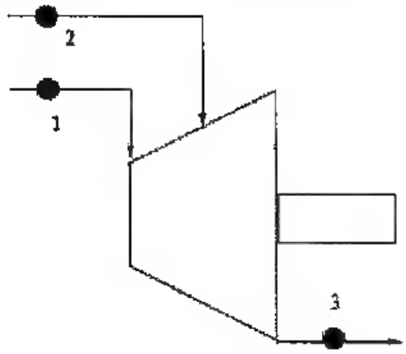

Figure 3

Question 4 (20 marks)

a) An inventor has developed a refrigeration unit that maintains the cold space at -8 °C, while operating in a 25°C room. A coefficient of performance of 8.5 is claimed. How do you evaluate this? (5 marks)

b) Steam enters an adiabatic turbine at 3 MPa and 800 °C, with a steady flow of 1.28 kg/s. The exit pressure of the turbine is 100 kPa. It is claimed that the turbine can produce $\dot{W}$ = 1.5 MW of power. Could this claim true? Justify your answer with entropy generation calculation. (10 marks)

c) A heat engine receives heat from a source at 1000 °C and rejects the waste heat to a sink at 50 °C. If heat is supplied to this engine at a rate of 100 kJ/s, determine the maximum power this heat engine can produce. (5 marks)

Question 5 (20 marks)

a) Air as an ideal gas is contained in a well-insulated rigid container and receives work input. Will the entropy increase, decrease, or remain the same? Explain. (5 marks)

b) An insulated open feed-water heat exchanger has two inlets and one outlet. At inlet 1, water vapor enters at 10 MPa and 550 °C. At inlet 2, liquid water enters at 10 MPa with an internal energy of 416.23 kJ/kg. The mass flow rate is 10 kg/s at each inlet. A small stirrer mixes the two streams together inside the heat exchanger. The work done by the stirrer is 10 kW. The exit pressure is also 10 MPa.

i) What is the exit temperature of the stream in °C? Locate the inlet and outlet states on a P-V diagram. (8 marks)

ii) What is the entropy generation in the heater? (7 marks)

Continued ...

Appendix 1

Uniform State Uniform Flow (Unsteady Flow)

Continuity:

$$(m_2 - m_1) = \sum_i m_i - \sum_e m_e$$

First Law:

$$\sum_i m_i\left(h_i + \frac{V_i^2}{2} + gZ_i\right) + \sum_e m_e\left(h_e + \frac{V_e^2}{2} + gZ_e\right) + Q_i - Q_e + W_i - W_e$$
$$= m_2\left(h_2 + \frac{V_2^2}{2} + gZ_2\right) - m_1\left(h_1 + \frac{V_1^2}{2} + gZ_1\right)$$

Second Law:

$$m_2 s_2 - m_1 s_1 = \sum_i m_i s_i - \sum_e m_e s_e + \int_0^t \frac{\dot{Q}_{cv}}{T} dt + {}_1S_{2\,gen}$$

Ideal Gas

Ideal Gas Equations of State

$$Pv = RT$$
$$dh = C_p dT$$
$$du = C_v dT$$

Specific Heats and Ideal Gas Constants

$$C_p - C_v = R$$
$$\frac{C_p}{C_v} = k$$

Entropy Relationships

$$\begin{aligned} s_2 - s_1 &= C_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1} \quad \text{if constant } C_v \\ &= C_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1} \quad \text{if constant } C_p \\ &= s^0_{T_2} - s^0_{T_1} - R\ln\frac{P_2}{P_1} \quad \text{otherwise} \end{aligned}$$

For polytropic process

$$PV^n = c$$

$$\begin{aligned} {}_1W_2 &= \frac{P_2V_2 - P_1V_1}{1-n} \quad n \neq 1 \\ &= P_1V_1 \ln\frac{V_2}{V_1} \quad n = 1 \end{aligned}$$

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